

NOTE ON IRRIGATION
IN THE
BIKANER STATE,

BY
THE CONSULTING ENGINEER FOR IRRIGATION IN
RAJPUTANA.

1905.

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Note on Irrigation in the Bikaner State,

RAJPUTANA.

Physical Aspects

1. The area of the Bikaner State is 23,311 sq. miles. It is bounded on the North-West by Bhawalpur, a Mohamadan State; on the North-East by the British Districts of Sirsa and Hissar in the Punjab; on the East by Jaipur; on the South and South-West by Jodhpur and Jaisalmere.

The Southern and most of the North-Eastern portions of the State form a portion of the vast sandy tracts known as the Bagar; the North-West and part of the North are in the great Indian desert.

The North-East corner adjoining Sirsa is the least unfertile section, as in good years it is well flooded by the Satra. From the city of Bikaner, South-West to the Jaisalmere border, the country is hard and stony, but throughout the greater part of the territory the plain is undulating or interspersed with shifting sandy hills from 20 to over 100 ft. high, whose slopes, slightly furrowed from the action of the Wind, suggest the ribbed appearance of the sea shore. Generally speaking the villages are far apart, and though grass and Jungle bushes here and there abound, the aspect of the country is dreary and desolate in the extreme. Trees are rarely seen. During and after the rains, the country however wears a very different aspect, becoming a vast green pasture land, covered with the richest and most succulent grasses.

Absence of rivers or streams.

2. The Bikaner State contains no rivers or streams. In the rainy season a "nallah" sometimes flows from Shekhawati over the eastern border but is soon lost in the sands.

The Ghaggar called also the Sotra or Hakra in the Punjab, once flowed through the northern part of the Bikaner territory; but it is now dry, and wells are dug in its bed, where it is said the only sweet water in that region is to be found. During the rains however it sometimes contains water for a few miles of its course, and the Tibi, Hanumangarh and Suratgarh Perganahs are greatly benefited by it. By the construction of headworks at Otu near Sirsa in the British territory, the water of this river is now utilised for feeding two canals, which form the most important Irrigation works of the State (see para 13.)

Some water from the Western Jamuna canals occasionally enters the State, West of Hissar.

The sometimes superfluous water of a branch of the Sirhind Canal also occasionally waters a few villages, lying in the north of the State but Irrigation from this source is always uncertain.

3. Two little fresh water lakelets formed by the drainage off the rocky country South-West of Bikaner, lie on the route from Bikaner to Jaisalmere. The first *Gujner*, about 18 miles from the capital, has clear water and a wooded margin. It is perhaps the only pretty spot in the Territory. There is here a Palace and a Garden watered from the lake.

Small
lakelets

The other lake is situated at *Kolait*, 12 miles further on. It is a place of sanctity and there are bathing ghats and some fine *Pipal* trees.

Both these Tanks depend on the rainfall, and the water in them dries up in years when the fall is small, a frequent event in Bikaner.

4. The lake of *Chhapar*, in the *Sujangarh* district, was the principal source of the salt supply of Bikaner, but it is now closed in accordance with a treaty with the British Government. Mr. Standley, the State Engineer, notes on this as follows:—

Chhapar
brine
lakelets.

“*Chhapar Bund*—There is a small range of hills in the South-West corner of the State a few miles from *Chhapar* and *Sujangarh*. There is a well defined nallah that comes down from these hills and finally loses itself near the village of *Gopalpura*. When they have fairly heavy rains, the water fills the “*Thal*” near *Chhapar* for one or two feet, and I am told stays there for over a fortnight and I am given to understand that no use is made of that water. I think the soil in parts there, is a bit saline. A survey of the whole catchment and “*Thal*” with all the nallas will be made this year, and it will then be decided what is the best thing to do with the water, whether to store it or to utilize the flood water straight as it comes down, by diverting it to lands where crops could be raised.”

5. From want of water, trees are scarce in the State. There is an extensive belt of *Babul* trees near *Hanumangarh* selfgrown which stretches for about 10 miles in length, with a width varying from 2 to 4 miles along the dry bed of the *Ghaggar*. The *Nazim* of *Hanumangarh*, *Laljimal*, an intelligent and capable officer strongly advises the clearance of all the larger trees in this Forest. He says nothing can be now grown on this land, that sooner or later when the trees decay they will realise little; where as if sold now, there would be considerable profit on the wood, which owing to the proximity of the Railway can be easily disposed of; and while the younger trees could be growing up the land which is good soil could be cultivated, and as it is commanded by the *Ghaggar* canals, could be irrigated and bring in a good return.

No Forests
Babul trees
near
Hanuman-
garh.

In a treeless country like Bikaner, one naturally hesitates to recommend cutting down trees anywhere; at the same time the reasoning of the *Nazim* is sound, and it rests with the *Darbar* to sanction it or not.

Perhaps a portion of the area might be cleared as an experiment. The result would shew if it was desirable to do more or not.

There is a branch line of the Railway already made from the station on the main line to the town of *Hanumangarh* which will facilitate the removal of

wood. All Bikaner may be said in the rains to be a pasture ground; about Hanumangarh to the North, the grazing is famous, but after rain, good grazing is almost everywhere to be found.

Rainfall

6. The rainfall is exceedingly capricious and uncertain throughout the State and on account of its geographical position the country is liable to constant droughts and to frequent cycles of continuous deficiency in the monsoons. The average rainfall of the 4 administrative divisions based on statistics for the years 1891 to 1900 is as follows:—

Bikaner	...	...	9.84
Sujanagarh	...	...	13.60
Reni	...	...	12.57
Suratgarh	...	...	9.81
and for the whole State	...	...	11.45

The rainfall is generally better in the Eastern Tehsils, than in the Northern and Western portions of the State. It seems to diminish steadily from East to West. The average rainfall in 1898 amounted to 6 inches 11 cents or a little over one half the normal. In 1899 it amounted to only 3 inches 6 cents or about $\frac{1}{4}$ th of the normal; the Kharif was a total failure; as of 841383 bighas brought under cultivation, crops were produced on only 5623 bighas. The Rabi of 1900 was also extremely bad. Owing to the scarcity of fodder the loss of cattle was very heavy and is estimated at $\frac{3}{4}$ of the number existing before the famine. The State entirely depends on rainfall for its agricultural prospects.

Personal Interest taken by H. H. the Maharaja in Irrigation.

7. The Maharaja of Bikaner is keenly alive to the welfare of his State, and evidently takes an interest in Irrigation, and knows the benefits that are derived from it. At a State banquet to Sir Arthur Martindale A. G. G. for Rajputana on the 14th January 1905 in his speech alluding to Irrigation he said:—

“During the present financial year Rs. 20,000 have been devoted to providing wells for Irrigation, improving existing tanks and wells and making new ones where required in the districts, besides Rs. 10,000 set apart for Irrigation, wells, &c., in the Revenue Department Budget, and it is proposed to make similar arrangements in future years. With the help of Mr. Standley, our Executive Engineer, who has had considerable Irrigation experience, we are, wherever possible, also arranging for the construction of Irrigation works.

A bund at Mudh in the Magra tract, estimated to cost about Rs. 20,000, is nearing completion, while some other projects have been surveyed and are under consideration.

We have taken advantage of the Government of India's kind offer of assistance by inviting Col. Sir Swinton Jacob here towards the end of this month who will personally visit the projected sites and further advise us.

Of course in my state, such places are few and far between, and although it is too early yet to speak more definitely, we are inclined to think, that another canal can be brought into the State and we hope later to ask for assistance from the Government of India and yourself in the matter."

The Maharaja in his tours of inspection has personally made investigations with reference to Irrigation. In the last Administration Report it is noticed that after a heavy fall of rain he went to inspect some places which were considered suitable for Bunds etc., for Irrigation purposes.

In January, 1904 he visited Otu, the headworks of the Ghaggar canals with the Superintending Engineer for Rajputana, Mr. G. G. White; the Revenue Secretary, and the State Engineer (Mr. Standley); where a conference was held with the Government Executive Engineer in charge of the canals relative to various points in connection with the canals, which are considered unsatisfactory and prejudicial to the interests of the State and these matters were discussed.

He also went to Pakki and Kotha and "inspected the small canal at the latter place which used formerly to supply water to the Bikaner villages but no water has lately been received from the Punjab side for Irrigation purposes."

In January, 1904 he also visited Sulkhania to note the effect of water during the rains from the Katli River, from the Shekhawati side in the Jaipur State.

His Highness also came with us to see the work at Madh and the sites at Pilap and at Chandni, places he had himself discovered as suitable he hoped for Irrigation Works.

All these instances show the personal interest which the Maharaja takes in the subject.

8. The land is assessed at the following rates per acre.

		Maximum			Minimum.			
Wet land	...	Rs.	2	11	3	...		
Dry "	...	"	0	6	0	0	4	0

Rates of
assessment
average
yield of
crops.

The average yield of crops in cwt., per acre is as follows:—

Bajra $2\frac{1}{2}$ cwt., Moth $2\frac{1}{2}$ cwt., Wheat $5\frac{3}{4}$ cwt., Barley 7 cwt., Gram $9\frac{2}{11}$ cwt., Mustard seed $3\frac{1}{4}$ cwt., Rape seed $4\frac{1}{7}$ cwt.

Rotation of crops is unknown, as the State produces only one crop in the Kharif season, except a small portion of it, where the Rabi is sown in the succeeding Kharif, so as to obtain the full advantage of the superior tillage.

9. The Khalsa portion comprises about $\frac{1}{2}$ of the State, the remaining $\frac{1}{2}$ includes the Jagirs or Estates of Thakurs.

Population.

10. In 1881—509,021. The decline in 1901 was due to the great
 1891—831,955 scarcity and famines of 1891; 1892; 1896,
 1901—584,627 - 1897; 1899,- 1900 and the consequent
 migration of the poor and affected people to the adjacent districts of the
 Punjab, Bhawalpur and Sindh. Although population is likely to increase
 wherever water is obtainable and other conditions are favourable, the scarcity
 of population over the greater part of Bikaner and the larger area taken up by
 the ranges of sand hills, will form serious obstacles to Irrigation; in fact, in
 a great portion of the State, will make it impossible. Still there are directions
 in which it is believed something may be done and these will be considered
 further on.

The agricultural and pastoral classes of the State comprise according to
 the last census 71·03 per cent of the total population or 415,261 souls. The
 percentage on the agricultural population of actual workers are 62·86 and of
 dependents 37·14 per cent.

The agricultural community is for the most part poor; their camels, kine
 and sheep are a great resource to them.

In the central sandy track of the State there is practically only one har-
 vest, the Kharif; Rabi cultivation, and that only in years when rain falls at the
 proper time, is confined to the Suratgarh Nizamat, to the two Eastern Tehsils
 Nohar and Bhadra, to a small area in the North-East corner of Tehsil Rajgarh
 and to the Tehsil Sujangarh. In the more sandy portions the Kharif crops
 consist almost entirely of Bajra and Moth. A very small quantity of Til and
 Jawar are sown in the more level and loamy spots.

The principal Rabi crops are Barley and Gram mixed. Next to these
 Rape seed occupies the largest area and it is the chief Rabi crop in the Surat-
 garh Tehsil.

In the portion of the Nali area reached by floods, Wheat is sown.

The State produces some excellent fodder grasses in various parts and in
 years of good or fair rainfall these places are among the best grazing ground
 in India.

Villages.

11. The number of villages is 2101 but villages in Bikaner are so fre-
 quently abandoned and repopulated that the number existing at any time can,
 it is feared, never be precisely ascertained.

Villages are situated at considerable distance from one another; this and
 the sandy ridges which extend for miles around them, make Irrigation hopeless
 in a large portion of the State.

Famine.

12. Though Famines are frequent, the mass of the people possess no
 store of grain wherewith to meet them, and when they occur, either migrate
 or depend on charity or grass seeds.

In September 1891-92 when relief operations became necessary they were satisfactorily carried out by the Regency Council under the supervision and guidance of the Political Agent, Mr C. S. Bayley. The works consisted principally of digging of Tanks and the sinking of a few Wells.

In 1896-97 there was great scarcity, 25,000 to 30,000 persons are said to have left the country, of these one half is said to have returned. Nearly 33 per cent of the cattle are reported to have died in the area affected.

The relief works opened at the different centres, consisted mostly of digging of Tanks, but the two principal works on which people were largely employed were the Ghaggar canals and the Railway extensions.

The excellent way in which the Nazim of Hanumangarh, Laljimal, supervised Relief operations on the Ghaggar canals, appears to have merited approval of the British Officers who inspected them.

In addition to the State relief works the digging of two private Tanks was started by Thakur Jagmal Singh of Bai and Rai Bahadur Seth Kastur Chand Dagga, to help the people in finding employment.

13. No canal work has been done in the State except from the Ghaggar. Mr. Standley, the State Engineer supplies the following note:—

Allusion
to Ghaggar
canals.

"These canals used to be managed by the Hissar Division of the W. J. canal, but since April 1904, the Bikaner sections of the canal, have been handed over to the management of the State itself. These canals have been constructed since 1897 from which year too, they have been running. From the completion Report Rs. 6,19,100 were expended on their construction out of which Rs. 2,79,679 were paid to the British Government, as contribution by the Bikaner State. But beside the above sum the State spent Rs. 1,84,309 on canal Famine Relief Works, so that altogether these canals have cost the State Rs. 4,63,988 or Rs. 1,46,741 more than the anticipated Bikaner share provided in the Revised Estimate of 1900.

According to the figures supplied by the Revenue Department, it appears that the total receipts for 1897, the first year the canals were opened until end of March 1904, were about Rs. 69,000 "after deducting Remissions" *i. e.* averaging Rs. 9,900 approximately per annum.

The total amount paid to Government for maintenance and repairs and management etc. comes to Rs. 53,000 approximately, or about Rs. 7,600 per annum, that is the net benefit they were getting amounted to Rs. 2,300 per annum, which only represents about $\frac{1}{2}$ per cent on the capital outlay. However since we have taken over charge of the Bikaner section, things are looking better, we have done the biggest Kharif up to date this year *i. e.* 10,696 acres with a total gross Revenue of Rs. 23,714. The Rabi figures are not in yet but probably they will amount to 400 or 500 acres and will produce about Rs. 300 or 400 as the rate charged is only for Palao or 4th class rate.

Our total expenditure to date is about Rs. 7,000 and will probably amount to Rs. 10,000 by the end of March, so after deducting remissions etc. I expect the net profit will amount for the financial year to Rs. 8,000 or 8,500.

But there is still a lot to do to improve the channels and distribution of water. Large maps have been made showing all the outlets and water courses, and the fields, all high lands which are above command, unculturable soil, and good soil, so that at a glance, it may be seen where the water should be utilized to the best advantage; with the construction of several new minors and the reduction of the sizes of the present outlets, or the removal of those badly situated, it is hoped that a much bigger area will be obtained in future.

Both canals have been levelled with the object of being remodelled from the Border to the tail. Several new outlets were given and the South canal was extended a couple of miles about. It is hoped that the improvements contemplated will be enough advanced before the next rainy season to show a very marked result in the Irrigation during the next Kharif and Rabi seasons."

In his evidence before the Irrigation commission Mr. Sydney Preston speaking of the Ghaggar canals says in bad years they dry up and in wet years they carry water which no body wants, shewing the necessity for a better distribution of the water to lands which need it. "page 31 Question 275"

It will be seen that Irrigation has been carried out from these canals but the area irrigated depends upon the nature of the floods in the River. The brick culverts at the heads of the minors are not provided with shutters and the water is not under control, nor is it known whether the water is all properly used or not. It is quite possible that better returns will be got from these canals if these two points are attended to. It must be remembered that the value of water on good land is greater than on poor land.

It will be seen from Mr. Standley's note above, that he is quite alive to the importance of these points; the large scale maps he is having made will show what land is now irrigated, which is the good land and what improvements can be made. He evidently takes a keen interest in the work and the experience he has had in canal Irrigation will no doubt prove an advantage to the State. I consider the improvements he suggests very necessary and suggest that they should be carried out without delay. It is in the better distribution of the water and proper control that improvement is possible.

Tanks 14 There is no Tank Irrigation in Bikaner. The tanks as a rule are used for storing rainwater for drinking purposes. They are generally small ponds, often merely dug out of the ground and the earth thrown up into an irregular bank, and in years of deficient rainfall do not fill, or soon dry up.

The State Engineer (Mr. Standley) has prepared a memorandum on Irrigation Tanks, in which he gives his ideas as follows: "See Appendix E."

It will be observed he advocates a system of small Tanks of sufficient capacity and depth to hold the drainage of its own small catchment area

and to make no tank more than 20 acres in extent. The tanks to be made of one uniform width, and in order to minimise excavation, 165 ft. is the maximum width to be adopted, as it is a convenient lead for the Earthwork, and the rate can be fixed uniformly with reference to that type of tank. He suggests making the depth about 3 ft. perfectly level everywhere, as calculated to be enough to hold out against the effects of evaporation and absorption until about the 15th November and he gives a table shewing the probable cost of tanks of this type, from an area of one to twenty acres.

He allows that this is not the most economical way of storing water, but thinks it will be the best way of minimising percolation and absorption, and that the returns on a 20 acre tank "costing Rs. 11,000" will be about 2 per cent on its capital in any ordinary year of average rainfall.

He suggests Diatra, as a good place where a couple of 20 acre Tanks may be made; and data from these accurately obtained about evaporation, absorption and percolation, which will be of value in the design and construction of any future works.

I have not seen Diatra so am not able to give any opinion on this site, but before carrying out any work of this sort I think it would be well to ascertain what becomes of the water as it is; is it used anywhere? for I understand that in all these cases no water can escape, owing to the surrounding high ground; and that where it settles, as the water dries up, cultivation is now generally carried out. If so, unless better use can be made of the water, it is no use to spend money in storing it.

There would be the chance of the area excavated uniformly 3 ft. deep being silted up sooner or later in some places; still the conditions of the country are so different to what is met with elsewhere, that I feel diffident about giving a decided opinion; and would suggest careful enquiry and consultation with the Revenue officials and villagers concerned, before carrying out any project of this sort. If all agree as to the advisability, it will give confidence and if the Durbar approves, one tank could then be tried as an experiment to test it.

15. Notwithstanding the slight apparent difference in the level of the country, water is found at varying depths and is of very unequal quality. The wells in the city are more than 300 ft. deep but the water of most is of excellent quality while a few miles to the North and North-West, water is found nearer the surface; but frequently there is not above 3 ft. of sweet water; an inch too far and the stratum of brackish water is tapped and the well is spoilt for all practical purposes. The ordinary depth of subsoil water is 250 ft. to 275 ft. below the surface. Near the North, the water level is not so deep, it is about 100 ft. to 150 ft. perhaps. In the valley of the Ghaggar in flood time, the level of the water, it is said, rises, and sinks to 50 ft. afterwards. They grow Rabi in the flood water. They do not have enough water to irrigate from wells. A good pucca well 10 ft. in diameter it is said costs about Rs. 20,000. The people of the country depend a great deal on

Wells.

rain water; the surface drainage being collected either in covered pits or in simpler excavations. During the hot season the scarcity of water often causes great inconvenience if not suffering. Water in the city is sold. On the road travellers are said to be found dead sometimes for want of it.

The strata passed through in a well where water had been reached at a depth of 316 ft. were first a mass of kunkur, then red clay, thirdly sandstone; and lastly white gritty sand or gravel; the latter consisting of white stones from the size of a pea to that of an egg, composed of quartz, and although not round, yet with surfaces and angles so smooth as to give rise to the idea that they must at some time have been exposed to the action of running water.

In a well at Palana about 14 miles South-west of the Capital, at a depth of about 220 ft. lignite, approaching coal in quality, has been found and a colliery is being now worked there; proving that forests must at one time have covered this area.

Unao or
Tals. 16. There is one feature in Bikaner which is not met with in the other parts of Rajputana which I have inspected.

There are depressions among the sand hills where good soil is found and where after a fall of rain, the surface drainage collects, and as there is no outlet, owing to the high ground all round, the water stays for a few days, sometimes longer. The quantity collected depends upon the nature of the surrounding country. In some places where the ground is hard and free from any jungle, it may often be as much as 20 per cent or more with ordinary rainfall.

As the surface dries up, the bed is cultivated and good crops of grain are produced. These places are easily recognised by the vegetation, trees and bushes which flourish wherever water has passed or is near. A good instance of such a place is at Chandni, about 20 miles South-west of the Capital. The water for some days after the rains stands in the Jheel or Unao and forms a small lake, apparently about a mile long and half a mile or so in average width and is said to be about 4 ft. deep in the deepest part. For some months after the rains, water is found below the surface here, so the villagers say, for a depth of perhaps 20 ft. but not below this. The water in the village well is over 200 ft. from the surface. From the Jheel none of the water escapes, only that of a nallah on the west which is absorbed by the sandy ground on its way to the Jheel, is lost. This is alluded to in Appendix C.

Any attempt to intercept the feeding nallahs to this Jheel, would therefore appear to be only throwing money away, as all the water which now reaches the Jheel is made good use of.

Another instance is at Gujner about 16 miles west of the capital, where all the water that flows off the surrounding ground is caught by a bund where the depression begins, and forms a lakelet, about half a mile long by about a quarter of a mile wide and is perhaps the most picturesque spot in Bikaner. A garden and some garden palaces have been erected on the bund and below it,

and the place is surrounded by a small forest of trees, an oasis in a desert. Below the bund, the natural valley or depression is good soil, capable of cultivation.

In this instance the water instead of being allowed to overflow the depression has been stored and supplies water to the gardens below it and affords pleasure.

Whether it is advisable to attempt to store water in similar places, or to let it overflow the ground below and cultivate the bed as it dries up, is a question which will depend upon local circumstances; generally speaking, I should be inclined to say it would not pay to store the water. It might, or a large portion of it, possibly be absorbed inside the bund in some places, before it was required and so be lost.

At the same time it is possible something may be done to increase the supply to some of these Jheels, either by making cuts on a contour line, with a small slope, say of 1ft. to the mile, to intercept surface drainage, on the supposition that it would not interfere with the supply to other rights and lead it to the proper places, or to prevent it being absorbed by the sand, before it is lost. (see remarks Appendix C.)

At Gujner the opportunity might be taken to check the run off the catchment. The drainage area and the contents of the Tank at every foot being known if the rainfall is registered, it would enable the run off to be accurately ascertained; this information would be useful in the preparation of many similar projects.

When all the land round such depressions cannot be cultivated, it might be possible to sow or plant trees, such as readily grow in such places, protecting them, while young, from being destroyed by cattle.

As it appears that the water which finds its way from higher ground to these depressions is generally made some use of; before attempting to bund up any of the water courses shown on the topographical map or seen on the ground, it will be advisable to ascertain what becomes of the water; is it made use of? and how?

If it is not, and it can be made better use of, either by increasing the supply or by storing it up, measures should be adopted as soon as possible, to do what is advisable. Not a drop of water should be allowed to be lost to the State.

It may be that more use can be made of some of the existing Unaos by getting settlers to take up land round the margin; if so, liberal terms should be given to induce cultivators to settle at such places.

It is suggested that every Jheel or Unao and every water course in the State should be systematically investigated, numbered and entered on a statement for record. At present it is not known whether anything can be done with

them or not. But I understand Mr. Standley is trying to do this. Something may be found to be possible so as to make better use of the water or of the land influenced by them.

Works and
sites
inspected

17. The following works and sites were inspected and notes on each are attached. The remarks in the inspection Notes have been given rather in detail, as Irrigation from Storage Tanks has not been started yet and details from experience elsewhere may be useful.

At Mudh Bund in progress (see note Appendix A.)

Site at Pilap Bund (see note Appendix B.)

Chandni „ („ „ C.)

The Talwara and Surawala Swamp (Appendix D.)

Katli Nadi
Project

18. The State Engineer, Mr. Standley, submits the following remarks on the Katli Nadi Project.

“ This is a Nallah that comes into the Bikaner State after flowing through Shekhawati in the Jaipur State. It enters the East of the State at a place called Sulkhania and penetrates the State for about 10 to 16 miles according to the nature of the flood. This year 1904 two floods came down and I am having the flooded area mapped out. The Nallah and its branch are being surveyed carefully and it will then be decided what is the best thing to do with the water. No project will be attempted until the dispute about some Bunds made in the Nallah in the Jaipur State has been settled.”

The decision not to attempt any project until the dispute about the Nallah has been settled with Jaipur is sound.

The arguments on both sides are contained in correspondence which has taken place as per margin.

Letter No. 31/171/00, dated 7th January 1904, from the Secretary Political and Foreign Department Mahkma Khas, Bikaner, to the Political Agent Bikaner.

From the Political Agent Bikaner, No. 89 dated 12th January 1904, to the Resident, Jaipur.

Letter No. 974 from the Jaipur Council to the Resident at Jaipur dated 17th May 1904.

noted in the margin shew that there are two sides to the question.

Having been personally connected with the subject while in the Jaipur State, I prefer to allow the question to be taken up, when necessary, by some one unconnected with either State. These letters

Shallow
Embank-
ments

19. It is possible something may be done in the way of shallow embankments on flat lands; to hold up for a short time some of the rainfall or surface drainage, so as to make better use of the water; and to cultivate the submerged area when the water has been let out. In the short time available, it has been impossible for me to follow out such ideas, but the principle should be borne in mind.

The subject appears to have been alluded to by the Irrigation commission, as they asked the Diwan of Bikaner, if he did not think it would do some good on the stiffer soil to put embankments round the fields, but he was unable to say whether much could be done in this way.

The question was then put to him. "Supposing you get 10 in. rainfall say 5 in. sink in and 5 in. flows away, if you had embankments round the fields, would that not make a difference?" to which he replied. "They do not want much water for a kharif crop, they never cultivate the land; they simply plough in front and sow behind, as they go along. There would not be enough water for rabi or for crops of cotton; there is only enough for the inferior grain they grow."

20. On the 2nd February, 1905, I went with Mr. Standley, the State Engineer, to inspect the northern part of the State and reached Hanumangarh (144 miles) at 7 p. m. Sutlej River Project.

At Suratgarh about 110 miles North-North-East of Bikaner, the Railway crosses the dry bed of the Ghagger river. The aspect of the country changes at once. Up to Suratgarh the line passes through a desolate country, with ridges of sand, more or less sparsely covered with jungle scrub, but in places waves of loose sand, with here and there a small area of more even ground. Water is generally at a great depth below the surface and the train brings a supply with it for some of the road side stations. Villages are small and many miles apart and we rarely saw a human being. A more hopeless country for Irrigation it would be difficult to find anywhere.

At Suratgarh one leaves all this behind and enters on a flat alluvial plain covered with better vegetation, and villages appear more frequently. The soil with few exceptions is good, all it needs is water. Even as it is, when there is a normal rainfall nearly all the flat area for miles is cultivated and yields an abundant harvest. The country slopes very gradually towards the West and it would be difficult to find a country better adapted for Inundation or Irrigation. Here and there one sees mounds of a reddish hue caused by the remains of broken bricks and utensils of common red baked clay, which indicate that these were once the sites of villages, some of considerable size. It would appear that in former times this region was well peopled and that a mighty river once flowed here.

The following remarks taken from the Manual of Geology of India part I, page 416 are interesting.

"It is certain that in no part of the great Indo-Gangetic plain have more important changes taken place since the dawn of history than in the neighbourhood of the watershed between the Indus and the Ganges.

The traditions of the Hindus point to a time when a great and sacred river, the Sarasvati ran in the extreme East of the present Punjab, between the Sutlej and the Jumna. The modern Sarasvati is an unimportant stream fed by small tributaries from the other Himalayan ranges, deriving none of

its waters from snows, becoming nearly dry in the hot season, and losing itself in the Rajputana desert. According to some traditions this river formerly followed an independent course through the desert to the sea; and it is a curious fact that on some maps a stream bearing the name of Sarasvati is shewn running into the smaller division of the Ran at the head of Cutch. Another view, which is supported by stronger evidence, is that the Sarasvati formerly joined the Sutlej and that this pursued an independent course to the sea, under various names, of which the best known are Hakra, Sotra and Wahind.

The course of the lower portion of this old river coincides with the Eastern Nara in Sind, and the upper portion ran through a portion of the desert South-East of Bhawalpur, where numerous mounds and other relics of old cities remain to attest that the country was once far better watered than it now is.

It is an indubitable matter of history that the Beas, the Hyphasis of the Greeks, formerly did not join the Sutlej, but pursued a distinct course to the Indus, and the union of the Sutlej with the Beas is very probably due to the former river now running more to the westward than it did.

The diminution in the volume of the Sarasvati has been attributed to various causes, a decrease in the rainfall amongst others, and especially to the destruction of forest on the lower slopes of the Himalayas, but it is not improbable that Mr. Fergusson's suggestion is correct and that owing to the Sarasvati having raised its channel, whilst the Jumna has cut down its *khadar* the water which formerly supplied the former river now runs into the latter."

Further north from an inspection of the Topographical map, one sees clearly defined, parallel to each other, but a few miles apart, the dry beds of another River called Naiwal, all sloping to the west, shewing that the whole country was at one time watered by rivers from the North-East which probably joined the sea lower down, of which the Ran of Cutch is now all that remains, and are now lost in a sea of sand.

It is clear that if water could again be induced to flow here, there is no reason why this area should not be one of the best cultivated parts of India, and a great part at least of it might be restored to its former state of prosperity. It is worth investigation at all events.

In the Topographical map, one sees also just outside the North-East corner of the Bikaner State, the whole of the country in British territory, covered with a net-work of canals, which all stop at the Bikaner border.

One naturally thinks, if only these canals could be extended lower this flat alluvial country, what a great benefit it would be. The demand for water however is so great in British Territory that it is said to be impossible to give a drop to the Bikaner State.

This may be quite true as the canals are now designed, or with regard to the supply of water now available.

Hitherto it has not been considered necessary to make provision for any land beyond the British border; happily, a more enlightened policy has dawned lately and it is being recognised that the native States are members of one great Empire and deserve the same consideration as other members, and every tie that binds the members together and shows that the Government recognises the truth, that all have the same interests, while being a mutual benefit, must help to unite the whole body and make the Empire stronger.

To speak of water not being sufficient, when in the rains there is the mighty Sutlej passing by and volumes of water are flowing to the sea, seems absurd. Water which is not made use of! while the country is only waiting for it. Water which if it could only be diverted in this direction to inundate or irrigate these districts, would do untold good and make Famine, in this region at least, impossible. The whole of the northern portion of the Bikaner State, roughly a tract about 2,000 sq. miles, perhaps might be benefited. Not only Bikaner but Bhawalpur also, and perhaps even parts of Jaisalmere; for there is a slope the whole way and villages on the North Western borders of Jaisalmere are about 100 ft. lower than the land on the North-West border of Bikaner.

The water is there, the land is waiting for it, the slope of the country is all in a right direction and there appears no doubt as to the feasibility of this great project, for the water once flowed here.

The following is a note by Mr. Standley, the State Engineer, on this subject.

"Sutlej Inundation canals. The North of Bikaner consists of very good soil, fairly level, with a slope from the border generally towards the South-West, there are few sand hills comparatively speaking, no wells to speak of, villages are far apart. The water in the wells is much too low to be made use of, for everywhere in the lowest part of the depressions, the spring level is fully 200 ft. below ground. Any thing would grow in this soil, if only it had sufficient water and at present there are miles upon miles of good country which would produce excellent crops if only there was water to develop it.

This cold weather, two trial lines of levels were run from the village of Mirzawala about 20 miles this side of the border in the North of the State towards the Sutlej, to see if the ordinary flood of that river commanded that portion of the country. One line was near to the East of Fazilka straight to the river, but the level of the floods are too low there to be of any use and the line was continued along the river as far as Firozepore. Here the floods give sufficient command to irrigate a great portion of the North of the State, fully 5 to 6 lacs of acres of the country could be easily commanded. When it was found that sufficient command could be obtained

near Firozepore, a line of levels was taken from the river at that place to Mirzawala, along a probable alignment for a cut, so as to see the configuration of the country. This line, it is believed, passes through British territory, and does not go through any Native State. The sections show that if we go as far as Firozepore, any ordinary flood would, at a distance of 70 to 75 miles from the river, start commanding the lands of the State. But between the Bikaner border and the R. M. Railway fairly heavy embankment will be necessary, and from the border to the S. P. Railway fairly heavy cutting. The alignment is not the best one and I have no doubt that a much better one could be found. Just on the border as far as the S. P. Railway, is a high table-land on which evidently the whole present Irrigation channels of the Bhatinda and Abohar branches of the Sirhind canal have been aligned. All the minor channels of these branches command the North of the State, and as a matter of fact, several Bikaner villages near the border used to get a regular supply for Irrigation from the tail of the Abohar branch until about 2 or 3 years ago, when the supply was stopped, the surplus water being utilized elsewhere in British Territory. If the present Government channels could give us water during the rains, when they have no demand, or could be widened so as to take an extra supply to irrigate the North of Bikaner, our object would be attained to a certain extent, without entailing very heavy expenditure on Bikaner. If there are objections to the above suggestions, an alignment for an Inundation cut would be along the Abohar branch of the Sirhind canal with a probable weir in future across the river above the Firozpore "Kaisar-i-Hind" Bridge

The Punjab Irrigation officers knowing the country thoroughly well are competent to advise on the subject and will no doubt be able to help the State in this vital question.

What Bikaner requires is to get flood water at any cost, so as to be able to develop a large tract of country in the North now lying absolutely uncultivated and undeveloped.

To turn in the water of the Sutlej when in flood on to these lands, and fill in all available depressions, would mean an incalculable blessing.

The more water is poured into the country thus, the better it would also be for the lands situated on the Indus banks below its junction with the Sutlej, for it will afford an appreciable relief to the country which I believe gets regularly and disadvantageously flooded during the rains every year."

The above remarks shew that the State Engineer (Mr. Standley) has quickly seen the importance of this project, and in the short time that he has been at Bikaner he has done all he can to bring it forward. He has proved that the floods of the Sutlej above Ferozepore command the land in the North of the Bikaner State. The questions now are, which is the best route the water shall take? Shall it be an Inundation canal from flood water or a Perennial canal? Can water be stored anywhere? etc. These questions and

all details require to be thrashed out by a competent body of Irrigation experts. It is here that the Imperial Government can afford help.

It is not known whether the Imperial Government have any proposals for making another Weir on the Sutlej or of utilising the flood water of this or of any of the Punjab rivers so as to be able to afford a supply to the Bikaner State; or whether it will be possible to reap any benefit from joint action with the Bikaner State, or whether the lands on the banks of the Indus lower down, would derive any benefit from diminishing the floods in the Sutlej as suggested by Mr. Standley; be that as it may, the great benefit that would, I believe, be derived, would be enough to warrant the Bikaner State going to any expense to secure the object in view. The land is longing for water, let it be brought under any conditions and in as large a quantity as possible.

The Bikaner State however is not in a position to undertake the surveys in British territory or to prepare a large project of this sort. There are many matters of detail, and many difficulties probably to be considered and overcome. The Bikaner State can not do any more than it has done. It is now that the Imperial Government can come forward with a helping hand.

This appears to me to be the only hope of anything really being done in the way of Irrigation in the Bikaner State. The Imperial Government only has the power to deal with the matter. It is a great opportunity for making use of the water which is now all going to waste. It is the only way in which Famine in these parts can be met with any hope of success. It is an opportunity of restoring the prosperity which it once enjoyed, to a country now often a waste from want of water. It is an opportunity of doing a work of untold benefit to the country generally and to the Imperial Government; it is an opportunity, by its help and co-operation of drawing closer the bonds which unite and strengthen some of the members of this great Empire. One of the questions put by the Irrigation commission to a distinguished Punjab Irrigation officer was, "Is it not the case that Government should consider themselves responsible for all development of Irrigation all along the Punjab rivers. The answer was "yes." (Mr. S. Preston page 30, question 253) and he adds "expenditure by Government on such projects would unquestionably be financially profitable". (245)

Is it necessary to say more? or to suggest a more worthy object?

What is wanted is—

- (1.) To get proper plans and estimate prepared for the best way of dealing with the flood waters of the Sutlej, with the object of Irrigating or Inundating the waste lands in the Bikaner State and perhaps other States.
- (2.) To provide the funds.
- (3.) To carry it out.

At present we are only concerned with the first step. The Bikaner Durbar ask the Government of India to take the matter up, by appointing a competent staff to prepare Plans and Estimate and to submit a Report, and I am informed the Durbar are prepared to pay all the expenses which will be incurred in doing this. So that it will cost the Imperial Government nothing to comply with this request.

When this has been done, it will be time enough to discuss the other two points *viz.*, to provide the funds and give the sanction to carry it out. A bold and liberal policy is essential. The want of it has often prevented the Government reaping the full advantages elsewhere which might have been realised; and so necessary is it to realise this fact, that I take the opportunity of adding here the following extracts of the evidence given before the Irrigation Commission by some of the ablest Irrigation Officers in the service. The remarks have a connection with this subject and are the opinions of officers qualified to speak upon it.

Extract
from the
evidence
given
before the
Irrigation
Com-
mission.

21. Vide selected evidence before the Irrigation Commission, Appendix page 43 Col. S. L. Jacob, C.S.I., R.E., "The first essential is a profound belief in the possibilities of Irrigation and great boldness in attacking the problem."

"It is due to the lack of this belief, and to the caution which has so often characterised the dealings with the questions that have arisen, that the successes attained have not been even greater than they are."

Page 44. "There need be no fear as to the construction of Weirs across the Punjab rivers, even the mighty Indus itself will eventually have to submit to being bound, it being clearly understood that it is only a question of time for the remodelling of the whole system of Inundation canals."

"Water is to North-West India what its Iron and Coal are to England, or what Gold is to the Transval, but the great part of the water still runs away unused to the sea, and on the other hand much land lies barren and waste, or exposed to Famine, which could be watered."

"However difficult the problems may seem, they should be boldly attacked until it can be said that practically all the lands that need water have been provided for and not till then should water be allowed to run unheeded to the sea."

"Nor is there anything in these problems which would be so exclusively costly that a prosperous and wealthy department like the Irrigation, cannot afford to carry them out, and the ultimate result will be the far greater prosperity of the Province or (Provinces) as a whole, than if a more cautious policy be followed."

Page 46. "There is undoubtedly land available on the left bank of the Sutlej but only a very small portion of it is in British Territory. Some of

it would be in the Bikaner State, but the mass would be in the Bhawalpur State. This is a drawback, but on the principle of developing the whole country, it should be accepted that these lands should obtain the water."

"The Weir across the Sutlej would make a provision for the supply of the Inundation canals on the right bank which are supplied at present from that river."

"As to the proposed canal on the left bank it should be designed to command five million acres, for it will be able to irrigate nearly two million acres, and there should be room for expansion as the duties of the water are improved. It may, however, possibly be better to make two smaller canals instead of one huge one. Almost all the land embraced by such schemes is now practically desert land."

"The Sirhind canal irrigates up to the edge of the Ghaggar river. It is the tract between the Ghaggar and the Jumna which contains almost the whole of the Punjab which is subject to Famines; and the amelioration of its condition is perhaps the most urgent question of all."

Such is the evidence given by one of the most efficient officers in the Irrigation Department of the Punjab, and he sums up his remarks as follows:

Para 42. (2.) Let there be greater boldness in attacking the problems to be solved, and let these be taken up in a broader manner than has yet been done.

(3.) Inundation canals must be supplied from Weirs.

(4.) Use every drop of available water as far as possible, even if cheaper schemes can be designed, which entail waste of water.

(5.) Every bit of land which needs water, to be irrigated, if possible, even if the schemes be costly.

(6.) Famine to be looked upon as a blot and anomaly, and thoroughly combatted, money being freely given even to unremunerative schemes for this purpose.

(7.) The Indus water to be more fully utilised in Sind as well as in the Punjab.

(9.) The Beas cum Sutlej water to be utilised on the left bank thereof.

(10.) The tract between the Ghaggar and the Jumna to be more fully irrigated, each part being dealt with on its own merits.

Some of his remarks point to the lands in the direction of Bikaner, and I endorse every word most thoroughly.

Another Irrigation officer (page 58) Mr. G. M. Field, Officiating Chief Engineer says, "Enormous areas could be irrigated in Bhawalpur &c. by kharif canal.....All the Punjab rivers carry practically unlimited kharif or flood supplies.....If the principle of kharif Irrigation only be accepted, there is no reason why it should not be carried out at once on all Punjab rivers. The kharif canals however must be more or less separate from the perennial, as the practical difficulties of carrying an enormous kharif supply and a very small rabi supply in the same channel are almost insuperable."

Another officer the Honble Mr. J. Wilson C. S. I., Settlement Commissioner, Punjab recommends (page 34) that

(2.) "A complete survey should at once be undertaken of all the river valleys of the Punjab, river by river, with the view of determining what can best be done to maintain existing cultivation, to restore abandoned cultivation and to provide facilities by means of Inundation canals for the improvement or extension of cultivation."

And on page 35 he adds.

"There are untold millions of acres in the Rajputana Desert which it is quite feasible to irrigate from the Punjab rivers. I anticipate a time when the flood water of these rivers will be poured over vast tracts to the South and East, giving them sufficient moisture for the ripening of an autumn crop and the sowing of a spring crop and raising the under ground water level sufficiently near the surface, to enable the people to ripen their spring crops by means of wells and it is towards this end we should shape our policy."

"My recommendations therefore are that the waters of the Punjab rivers should be carried as far to the East and South as possible."

The precarious nature of the rainfall in the zone in which the Bikaner State is situated about, 10 or 11 inches, is a strong claim for consideration. In good years a large area of crops may be sown but in years of drought they either cannot be sown, or fail entirely; practically no crops are matured except with the aid of Irrigation.

The Bhawalpur State too is looking to the Sutlej; for Col. Grey, the Superintendent (page 8) says in his belief "that the Nawab is fully persuaded of the benefit that would be derived from a Weir to take off the water to his State." In fact all the States on the left bank of the Sutlej have been looking to the Sutlej for some years past.

Khan Bahadur Sahib Zadah Hamid Uzzafar Khan, the Dewan of the Bikaner State, asked the Irrigation Commission in November 1901 if they could not get a supply of water from the Sutlej river, and he described what he thought might be the alignment on the map but he had no data to press the subject home to the consideration of the Commission.

22. I most earnestly commend the subject to the favourable consideration of the Government and trust orders may be issued to meet the request of H. H. the Maharaja of Bikaner for the preparation of the Project and that nothing will prevent this great work sooner or later from being carried out in a spirit worthy of a great Empire.

The matter
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considera-
tion of
the Govern-
ment of
India.

S. S. JACOB. COL.

Consulting Engineer for Irrigation,

in Rajputana.

February 1905.

APPENDIX A.

Note by the Consulting Engineer on the Bund at Madh.

This Project is described by the State Engineer as follows:—

“Madh Bund. Catchment area 8 sq. miles, principally hard kankary soil. Average rainfall taken from previous Statistics of Bikaner, 10 inches. On account of nature of soil 20 per cent run off has been estimated for. Length of bund 4,300 ft., capacity of tank 41,130,760 cubic feet at crest of Escape. Area of water spread will be 132 acres; greatest depth 13 feet; supposing the tank is filled up to crest of the Escape, it is calculated that after deducting propable loss by absorption and evaporation in the tank, there will still be nearly 28,000,000 cubic feet of water available for Irrigation. This spread over the ground to a depth of 1 ft. represents 643 acres. Amount of Estimate Rs. 16,192, cost of storage estimated at 2,540 cubic feet per rupee.

There is good soil below the bund within half a mile fit for Irrigation. Sluice head and channel have not yet been built.”

Judging from the hard nature of the catchment area, I do not think 20 per cent of the rainfall here, is too much to expect in ordinary years.

I would make the following suggestions.

1. The inner slope, below high water line at least, should be every where not less than 4 to 1; the soil is so light that probably this will not be enough, unless protected in some way. It will be advisable to do this work at once, while the tank is empty and earth is obtainable from the inside.

2. The portion of the inner slope above H. W. L. will probably require protection of some kind, such as rubble stone or pitching of some kind where the wash of the water will probably cut it away.

3. Where the upper or outer surface of the bund is made up of the light sand, which can be blown about by the wind, it will be necessary to cover it over with some better material, such as a good layer of the clay from the borrow pits inside, to make the surface compact, as it is at the North end for a short distance.

4. Small ridges of earth will be advisable along the top of the bund to divide the surface into small compartments or “Kyaries” to prevent surface water (from rain) collecting and guttering the outer or inner slopes. The object being to let the rain water on the top surface simply sink in quietly everywhere, not run off.

5. Such Vegetation and Jungle plants, as grow around, should be planted everywhere on exposed slopes, so as to help bind the surface together

6. I would suggest any trees that are in the bed of the reservoir and likely to be submerged, should be removed before the rains, or they may be lost.

7. The outlet sluice had better be put now, before the water fills the tank. The best place seems to be near the North-end where the sloping hard ground joins the plain, as there will be better foundations here than elsewhere.

The level of the outlet ought to be low enough to enable all or nearly all the water being taken off.

The best plan of outlet I think is a round or rectangular well, with round holes in cutstone, 6 in., or 9 in., in diameter, tapering towards the inside, fitted with tapering wooden plugs with heads on the water side. Projecting steps and a chain to be provided outside to enable a man to place the plugs from the outside and similar steps or slabs on the inside to enable a man to descend inside the well and knock out one or more plugs, when water is required.

A small culvert to lead from the bottom of the well underneath the bund to a small cistern outside, from which the Irrigation duct will start.

It is advisable to have a core wall of masonry extending at least 15 feet on each side of the culvert and above it, in the body of the bund, and to ram the earth well round it, to prevent any creep of water along the surface of the culvert; for the same reason the surface of the masonry should be left rough not plastered. A gauge may be marked on the outlet well to mark the depth of water.

8. The contents at each foot of depth of water in the tank being known it would afford useful data for future projects if a rain gauge is put somewhere in the catchment area and the percentage of run off compared with the rainfall.

9. It will be advisable to have a map prepared on a large scale say 6 in. to 1 mile at least if it has not already been made and to mark on it, all the land commanded and ducts proposed, noting the places where the best soil is found, so as to ensure Irrigation ducts being conveniently aligned to reach these places; also to get the revenue officers to inspect the place and arrange beforehand that full advantage may be taken of the water.

As it will take labour and time perhaps to prepare the ground, it ought to be given on liberal terms for the first year or two.

10. The main duct should be taken along the foot of the high ground on the North just above all the land which can be irrigated.

The duct may be 5 ft. wide with a slope of 1 or 2 ft. in a mile, the excavated earth being thrown 10 ft. clear of the duct so as to afford a Patri, and admit of the duct being widened easily hereafter if necessary.

The earth to be neatly dressed off and Babul or other seed to be sown in the rains on the outside of the bank in the fresh earth.

Where watercourses have to be crossed the simplest plan will be to have level crossings and to bank them across before the Irrigation begins.

It is well to have ducts everywhere in excavation so that the water surface is flush with the ground or below it.

11. Where branches take off, Pillars may be put with cut stone grooves in them across the main duct, and a similar size opening across the head of the branch. Planks may be placed in these grooves to raise and to divert the water when required for the branch, and being interchangeable the same planks will serve to close the branch afterwards so that the distribution may be under command.

12. Bench marks should be put in the bed at every 1,000 ft. and distance marks on the bank to indicate the spot and the distance. It would be well to have the main duct at all events ready before Irrigation is needed or there may be delay in giving water when it is required.

13. A Mahafiz should be appointed to look after the proper distribution of the water and a blank book be given him in which the details of the Irrigation daily if any, should be noted.

14. The water rate should be fixed on the area irrigated, a certificate being given to the zemindar stating the area irrigated and the amount due by him and a copy of this to the Revenue Officer to recover the amount in due course.

APPENDIX B.

Note on the Pilap Project

On 29th January, 1905, after inspecting the Madh Bund we drove across to Motawat and from there rode to the site of the proposed bund about 1 mile North, across the nallah which passes between Motawat and Pilap. The project is described by Mr. Standley, the State Engineer, as follows:—

“Pilap Bund. Catchment area nearly 17 sq. miles, principally undulating ground, hard in parts and sandy in others, average rainfall 10 inches, owing to nature of soil 10 per cent is here estimated as run off.

Length of Bund 6,500 ft. and about 8 ft. deep in deepest part. Capacity of Tank 42,671,000 c. ft.; area of water spread 243 acres. Supposing tank filled up to proposed full supply level, after loss by evaporation and absorption inside the tank, there will then be 18,371,000 c. ft. available for Irrigation. This spread to a depth of 1 foot represents 421 acres.

The total estimate for earth work in bund is Rs. 12,495. The two escape channels on each flank will cost Rs. 2,500, the total estimate comes to Rs. 15,000. The cost of storage comes to 2,840 c. ft. for 1 Re. The storage will probably be increased, for the bund instead of being left 13 ft. above bed of nallah will probably be increased by 2 ft. more, with very little additional expenditure. There is fairly level ground below the bund fit for Irrigation though a bit sandy. This bund will soon be started.”

The basin is flat and extensive, decidedly a good one. The catchment area appears to be generally hard and the nallah to be clearly defined. There appears to be good land below the site, and the site proposed, just below the junction of two nallahs, resting on high ground at both ends, to be the best available.

Unless the bund is made high enough to store all or most of the flood, there may be difficulty to dispose of the overflow.

I have not seen the plans as they are not ready, but would suggest in preference to any masonry escape in the nallahs or elsewhere, that the bund be made so high that any overflow shall be diverted over the natural surface which I understand is possible at one or both ends where it can spread over a large area and gradually pass off the surface without doing harm or cutting back. From the nature of the soil I do not anticipate much inconvenience from silt.

The disadvantages of having any masonry escape in a nallah of this sort are (1.) the expense; (2.) it limits the level of H. W. L. which can not

be raised afterwards except by some temporary expedient which in a place of this sort, does not seem advisable; (3.) if silt does come (which however is not anticipated here to any great extent) the kutchu bund across the nallah can be easily opened at any time and the bed be scoured out and the bund be closed again at little cost.

The Irrigation sluice may be put on the side where there is the most land to irrigate; and may perhaps serve for all the land on both banks, the water being taken across the nallah on an earthen bank well rammed to serve the land on the other side. An extra sluice can be easily put at any time if found to be necessary.

The same remarks apply here to the formation of the Bund, Outlet sluices, Irrigation ducts etc. as were noted on the Madh Project, so need not be repeated.

It is not known what, if any, use is made of the water of this Nallah before it loses itself in the country below. This should be ascertained and considered, as it may affect the project. It would not be advisable to spend money in storing water, unless the advantages of doing so, are greater than the benefits derived from its unimpeded course.

On this understanding the project as regards site and catchment seems to be a good one.

APPENDIX C.

Note on the Chandni Project.

On the 30th January, 1905, H. H. the Maharaja and Mr. Standley, the State Engineer, went with me to inspect this site. The description given by the State Engineer is as follows:—

“Chandni Project. To the South of the village of Chandni there is a broad well defined nallah that comes down and loses itself about one mile from the village. The nallah is fully 7 miles long, the catchment is narrow, in its wider part not more than 3 miles, averaging I should say $1\frac{1}{2}$ miles. On the right bank, ground is hard and the run off would probably be from 10 to 20 per cent, on the left bank mostly sand hills, where the run off will be anything from 0 to 10 per cent. All along the depression from Chandni to Kotri, in fact as far as Kolaith, the soil is excellent for Irrigation. Only, I should say, big floods coming down the nallah find their way to the good soil, small floods being absorbed by the band of sandy soil which separates the good soil from the place where the nallah begins actually to split up in several branches and to spread out in the open. It would be a good thing if it was made possible for all floods to reach the good lands. Small training bunds on either side at the place where the nallah loses its definite channel, and the bed dug out, so as to form a good straight and definite channel as far as the good land, would probably answer the purpose.

The survey for this project is being made and the best way to deal with the question will be more easily understood from the contour map, and the plan showing the different channels into which the nallah splits.

There is a good deal of water that comes down from the hard slopes to the west of the village and gives a certain amount of Irrigation during the rains to this and Kotri village.”

We rode up the course of the nallah a short distance to see the nature of the catchment, which is peculiar. On the East side of the nallah the ground is comparatively hard. On the West it is nothing but sand, the nallah flows at the foot of these sandy hills and brings with it a good deal of sand which as soon as the nallah debouches on the level ground and the water loses its velocity, is deposited over a strip of land about half a mile in extent and all trace of the course of the nallah is lost.

In a year of exceptional rain it may perhaps find its way on to the “Unao” or hollow depression.

Any bund constructed amid these sand hills would be liable to two serious drawbacks; the basin would probably be soon silted up and any water stored would soon be absorbed by the soil and disappear.

We then rode across the depression or "Unao" which is about a mile or more long by half a mile or so wide, composed of first class soil and is generally well cultivated and has many fine trees upon it, to the west side, to inspect the nallahs on this side.

It was strange to follow the course of these nallahs from a faint trace on the field to the clearly defined course where the nallah leaves the hard and higher ground.

It appears that all the water brought down by these small nallahs spreads out in a small lake as there is no outlet for it. According to the statement of the villagers the water stands for some days sometimes 4 feet or so in the deepest part and extends over an area of about a mile or more in length and about half a mile in width and as it gradually subsides, cultivation is carried on from lighter crops such as Juar, Bajra etc. at the margin, to Wheat in the lowest part.

Water is found below the surface it is said for some time at the depth of about 20 ft. but not below this. In the village well, it is over 200ft. deep. It will thus be seen that nearly all the water which falls is made good use of and it is very doubtful if it will be advisable to go to any expense to store water which is already utilised.

The only thing which suggests itself here is whether it might not be possible to lead the water from the nallah on the east side alluded to above, by a cut direct to the Jheel, before it has time to wander about and lose itself amid the sandy hillocks.

If this can be managed without the water bringing down much silt with it, this water would certainly be gained and would be added to the supply already received. It would cost little to do this and the villagers, who were spoken to on the subject, confirmed the opinion that this was all that could be done and that this would be an advantage.

It is possible that only in exceptional years of small rainfall they might want this extra supply, as the area which can be cultivated is limited but it would be advisable to have observations made in the rainy season, and the matter discussed with the revenue officers and villagers before expenditure is incurred.

APPENDIX D.

Note on Talwara and Surawala Swamp.

On the 3rd February, 1905, inspected the Talwara Jheel with Mr. Standley, the State Engineer; the Nazim Lalji Mal and the Tehsildar accompanied us.

Mr. Standley describes his proposals as follows:—

"After the reservoir at Otu has been filled to the desired level and the North and South Ghaggar canals are running, the surplus of the river Ghaggar is allowed to flow over the Weir into its natural bed; this flood water comes down into the Bikaner Border as far as Surawala about 3 miles within the Bikaner Border and where the flood is a heavy one, as far as Hanumangarh.

But generally speaking, the water comes down into the Bikaner border, fills the swamps at Talwara and Surawala to a depth of one or two feet and remains there until it dries up in October or November.

A stretch of country about 3 miles long and varying in breadth from $1\frac{1}{2}$ to 2 miles gets thus flooded and is overrun with coarse grass and nothing is being done to it.

The idea is to drain this big swamp by a cut in the centre of the bed of the Ghaggar and lead the water past Hanumangarh and spread it on the country there where it would be of great advantage. At present if the floods arrived late in the season, say in September, in the villages near the border, such as Talwara and Tibi, the floods do a lot of good, as some of the fields about get flooded, are ploughed and sown with Rabi crops. Provisions for these fields will be made by suitable openings in the tanks, or if these fields are debarred from flood water they can always be commanded from the South Ghaggar Canal.

At the border so as to prevent the flood from spreading low, a training bund with an opening at the lowest point of the bed of the Ghaggar from which the drainage cuts (working backwards,) will be made; the cut at first will only be made, 20 ft. wide by 3 ft. deep, but provision will be allowed by throwing the spoil more than 50 ft. on each side of the centre line, for widening eventually to 100 ft. if found necessary and profitable. The cut will eventually be about 30 miles long.

To drain the villages of Ellenabad the British Government had made a cut into the Anahai swamp and permission might some day be obtained to connect this cut with ours."

The Nazim Laljimal, a capable and intelligent official and the Tehsildar of Hanumangarh both express approval of this project. To drain this land and make use of the water which often lies wasted here on good land lower down, appears quite feasible and to be a good project.

The land is now said to be often water logged, but if drained will be cultivable. It is commanded by the Ghaggar canals so water if required can be supplied to it. No expense need be incurred in making surveys or preparing the project, as the country has all been contoured already; the lowest line can be easily followed and the water made good use of lower down.

I recommend this project to be carried out as soon as possible; experience will shew the size of channel necessary to carry off all the water which accumulates here, but a cut 20 ft. wide as proposed by Mr. Standley might be tried at first and enlarged afterwards if necessary.

APPENDIX E.

Note by Mr. Standley, Executive State Engineer, on Irrigation Tanks.

From my last inspection of the Magra District, I find very few possibilities of making bunds, as the catchment areas in most places are not sufficient for a moderate sized bund. There are some exceptions, such as Chandni where a well defined and broad nallah comes down from beyond "Harla" and which probably has a catchment of about 20 sq. miles. This will shortly be surveyed and an estimate submitted in due time. There is also a small but well definite nallah to the North of Chandni that loses itself in the plain to the South of Gujner about 3 miles or 4 miles away from the latter place. Here too I would advocate a bund, the soil in parts is very culturable and even if the water dries up quickly the bed could be easily cultivated during the Rabi.

2. For the greater part of the Magra District from Madh to Chandni and further South and from Bithnok to Chandni, a better way of meeting the problem in my opinion will be by small storage Tanks.

These are properly not for Irrigation purposes, but simply to store in ~~on~~ each tank sufficient water during the rains, which by the end of October or by the 15th of November will leave their beds sufficiently moist to allow of Rabi crops being sowed, trusting to winter rains for their complete maturity.

3. The country there consists of well defined broad plateaux with a general and gentle declivity to some central depressions. It is evident that except at an enormous cost it will be impossible to collect all the rainfall that falls on such plateaux and leading it to one main central depression where a bund could be made. The method besides being exceedingly expensive will be wasteful, the leading cuts will have to be so long, that the greater part of the water would be lost in its passage to the bund. The proposal now advanced, is to have a system of small tanks of sufficient capacity and depth to hold the drainage of its own small catchment area and no tank should be more than 20 acres in extent.

4. Roughly speaking, allowing 10 per cent as the run off, a square mile for each 1 inch of rainfall will give 233,300 cubic feet of water and to be on the safe side and make sure that the tank will fill in ordinary years, it will be better to estimate the average rainfall available as 5 in. during the rainy season. This rainfall therefore will give 1,166,500 c. ft. and limiting the catchment area to 2 sq. miles the amount of water available for that catchment will therefore be 2,333,000 c. ft. The tanks must be made of one uniform width and in order to minimise excavation, 165 ft. is the maximum width to be adopted, it is a convenient lead also for the earthwork and the rate

therefore can thus be fixed uniformly with reference to that type of tank. Supposing a tank 165 ft. wide is made and one mile long, the area of the tank will be exactly 20 acres and the depth will be about 3 ft. which is calculated to be enough to hold out against the effects of evaporation and absorption until about the 15th of November. The bed of these tanks should be dug out perfectly level everywhere 3 ft. deep and the earth thrown as spoil below tank without dressing but roughly, 50 ft. wide and 8 ft. high. At one end of each tank a gap could be left in the spoil, so that supposing more water than is required comes down and fills the tank, the surplus could escape down the slope and be caught by another smaller tank made at a suitable distance below.

5. I give below a tabular statement giving probable cost of tanks for 1 acre to 20 acres with their respective catchment areas,—

Area of tank	Width.	Length.	Catchment required.	Probable cost.	
1 acre	165 ft.	264 ft.	0·1 sq. mile	Rs.	550
2 "	165 ft.	528 ft.	0·2 "	"	1,100
3 "	165 ft.	792 ft.	0·3 "	"	1,650
4 "	165 ft.	1,056 ft.	0·4 "	"	2,200
5 "	165 ft.	1,320 ft.	0·5 "	"	2,750
6 "	165 ft.	1,584 ft.	0·6 "	"	3,300
7 "	165 ft.	1,848 ft.	0·7 "	"	3,850
8 "	165 ft.	2,112 ft.	0·8 "	"	4,400
9 "	165 ft.	2,376 ft.	0·9 "	"	4,950
10 "	165 ft.	2,640 ft.	1·0 "	"	5,500
11 "	165 ft.	2,904 ft.	1·1 "	"	6,050
12 "	165 ft.	3,168 ft.	1·2 "	"	6,600
13 "	165 ft.	3,432 ft.	1·3 "	"	7,150
14 "	165 ft.	3,696 ft.	1·4 "	"	7,700
15 "	165 ft.	3,960 ft.	1·5 "	"	8,250
16 "	165 ft.	4,224 ft.	1·6 "	"	8,800
17 "	165 ft.	4,488 ft.	1·7 "	"	9,350
18 "	165 ft.	4,752 ft.	1·8 "	"	9,900
19 "	165 ft.	5,016 ft.	1·9 "	"	10,450
20 "	165 ft.	5,280 ft.	2·0 "	"	11,000

6. It is hard to say what the financial results will be. There is no doubt that storing water in this way is not the most economical one for the estimated cost per 1000 cubic feet comes to about Rs 4, but still it will be the best way of minimising percolation and absorption and making a few acres of land culturable for Rabi crops whenever the average monsoon rainfall comes to 5 inches and above.

Supposing the average gross produce of an acre of Rabi cultivation comes to Rs. 50 which is underestimated and that the State takes $\frac{1}{5}$ of the gross produce, the minimum which a 20 acre tank will return on its capital, is

Rs. 200 leaving out the probable Irrigation dues which will arise from the surplus water available i.e., a 20 acre tank will return about 2 per cent on its capital in any ordinary year of average rainfall.

7. When a tank of this kind has been built, it should be strictly reserved for cultivation alone and placed under the Tehsildar of the district who will be able to collect the revenue due by the leaseholders of each tank. As it is not every year that all the tanks can be filled, as one year may prove to be a failure, it would be better perhaps if the State derives its revenue by taking a certain proportion of the gross produce per acre. The subdivision of a tank of 20 acres say, will be quite an easy matter for it is of one uniform width throughout, and $\frac{1}{20}$ of the length of the tank will be exactly an acre, so no yearly measurement of area cultivated are at all required, as the tanks could be easily portioned out and the subdivisions into acres fixed.

8. If a trial of this system is to be made, a certain sum say Rs. 20,000 must be fixed which will be spent on this kind of Irrigation Work alone. A very good place for a first experiment is Diatra, where a couple of 20 acre tanks may be made and accurate data about local evaporation, absorption and percolation may be ascertained, which will be of great value in the design and construction of all future tanks.

It is of course to be remembered that if there is any water left in the tank by the end of October, it could then be emptied and its water used for giving fields situated below enough moisture to allow of Rabi crops being also sown.
